JC11 Rec'd PCT/PTO 12 MAR 2001

FORM PTO-1390 (REV. 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **10191/1761**
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/786945

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED:
PCT/DE99/02156	**13 July 1999 (13.07.99)**	**11 September 1998 (11.09.98)**

TITLE OF INVENTION
METHOD AND DEVICE FOR DETECTING CDMA-CODED SIGNALS

APPLICANT(S) FOR DO/EO/US
Frank KOWALEWSKI

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have. been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☒ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Search Report (translated), Preliminary Examination Report and PCT/RO/101.

EXPRESS MAIL NO.: EL594611268US

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U.S. APPLICATION NO. (if known, see 37 C.F.R.1.5) 09/786945	INTERNATIONAL APPLICATION NO PCT/DE99/02156	ATTORNEY'S DOCKET NUMBER 10191/1761

17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EUROPEAN PATENT OFFICE or JPO $860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	8 - 20 =	0	X $18.00	$ 0	
Independent Claims	2 - 3 =	0	X $80.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$ 860	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 860	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$860.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: [signature] (Reg. No 41,172)

[signature]

SIGNATURE

Richard L. Mayer, Reg. No. 22,490

NAME

3/12/01

DATE

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26646
PATENT TRADEMARK OFFICE

09/786945
JC02 Rec'd PCT/PTO 12 MAR 2001

[10191/1761]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	Frank KOWALEWSKI
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	**METHOD AND DEVICE FOR DETECTING CDMA-CODED SIGNALS**
Art Unit	:	To Be Assigned
Examiner	:	To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to: --What Is Claimed Is:--.

Please cancel original claims 1 to 9, without prejudice, in the underlying PCT Application No. PCT/DE99/02156, and cancel substitute claims 1-8, without prejudice.

Please add the following new claims:

EL594611268US

9. (New) A method for detecting CDMA-coded signals $\underline{d} = (\underline{d}^{(l)}, \ldots, \underline{d}^{(K)})$, where $\underline{d}^{(k)} = (\underline{d}_l^{(k)}, \ldots, \underline{d}_M^{(k)})$, $k = 1, \ldots, K$, comprising the steps of:

determining a first detection solution $\hat{\underline{d}}(1)$ of CDMA-coded signals $\underline{d}$;

determining an (n+1)-th detection solution $\hat{\underline{d}}(n+1)$ for n = 1, ..., N as a function of the n-th detection solution $\hat{\underline{d}}(n)$ by assigning

$$\hat{\underline{d}}(n+1) = f(\hat{\underline{d}}(n))$$

where iteration for $n \rightarrow \infty$ converges toward multiuser solution $\hat{\underline{d}}_{MU}$ corresponding to

$$f(\hat{\underline{d}}(n)) \xrightarrow[n\to\infty]{} \hat{\underline{d}}_{MU},$$

if a quality of approximation solution $\hat{\underline{d}}(n+1)$ is not sufficient, assigning $n \rightarrow n+1$ and continuing performing the step of determining the (n+1)-th detection solution ;

if the quality of approximate solution $\hat{\underline{d}}(n+1)$ is sufficient, terminating the method and using $\hat{\underline{d}}(n+1)$ as an estimate of data $\underline{d}$ to be detected, wherein:

the function of the step of determining the (n+1)-th detection solution is given by

$$f(\hat{\underline{d}}) = \hat{\underline{d}} + \delta \cdot \underline{g}$$

with

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2} \textbf{ and } \underline{g}^T = A^H \cdot (\underline{s}^T - A \cdot \hat{\underline{d}}^T)$$

where matrix A is given by

$$A = \begin{bmatrix} \underline{b}^{(1)}_1 & 0 & \cdots & \\ \vdots & \vdots & & \\ \underline{b}^{(1)}_Q & 0 & & \vdots \\ \vdots & \underline{b}^{(1)}_1 & & \\ \underline{b}^{(1)}_{Q+W-1} & \vdots & & 0 \\ 0 & \underline{b}^{(1)}_{Q+W-1} & & \underline{b}^{(K)}_1 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & \underline{b}^{(k)}_{Q+W-1} \end{bmatrix}$$

with $\underline{b}^{(k)} = \underline{c}^{(k)} * \underline{h}^{(k)}$,

where $\underline{c}^{(k)}$ denotes the K different codes and $\underline{h}^{(k)}$ denotes pulse responses of K different linear transmission channels.

10. (New) The method according to claim 9, further comprising the step of:
converging toward a solution of a zero forcing block linear estimator for $n \rightarrow \infty$.

11. (New) The method according to claim 9, wherein:
symbols $d^{(k)}$ to be transmitted assume values of ± 1 or $\pm i$.

12. (New) The method according to claim 9, wherein:
solution $\hat{\underline{d}}^T(n) = A^H \cdot \underline{s}^T$ of a RAKE receiver is used as the l-st detection solution for starting the iteration.

13. (New) The method according to claim 9, wherein:
a first one of the detection solution for starting the iteration is set to zero.

14. (New) A device, comprising:

a data estimator for determining a first detection solution;

an estimate improver for determining an improved detection solution; and

a decision circuit for deciding whether to continue an iteration.

15. (New) The device according to claim 14, wherein:

the estimate improver includes a unit for calculating an estimated transmission signal, a unit for calculating standardized approximation term $\delta \cdot \underline{g}$, and an adder for calculating an improved estimate.

16. (New) The device according to claim 15, wherein:

the unit for calculating standardized approximation term $\delta \cdot \underline{g}$ includes a unit for calculating approximation term $\underline{g}$, a unit for calculating standardization factor δ, and a multiplier for calculating the standardized approximation term. b)

Remarks

This Preliminary Amendment cancels original claims 1 to 9, without prejudice, in the underlying PCT Application No. PCT/DE99/02156, and cancels substitute claims 1-8, without prejudice. The Preliminary Amendment also adds new claims 9-16. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE99/02156 includes an International Search Report, dated January 28, 2000, and an International Preliminary Examination Report dated December 14, 2000, copies of which are submitted herewith.

Applicant asserts that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: [signature] (Reg. No. 41,172)

Dated: 3/12/01

By: [signature]

Richard L. Mayer
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METHOD AND DEVICE FOR DETECTING CDMA-CODED SIGNALS

Field Of The Invention

The present invention relates to a method and a device for detecting CDMA-coded signals.

Background Information

CDMA offers the possibility of combining multiple discrete-time data streams into a total signal such that the original data streams can be recovered from this signal. Data streams can be recovered if the CDMA-coded signals are modified by different linear filters. The simplest possibility of data detection is called a matched filter. Better results are obtained with a RAKE receiver, as described, for example, by A. Salmasi, K. S. Gilhousen: "On the system design aspects of code division multiplex access (CDMA) applied to digital cellular and personal communications network," *Proc. IEEE Conf. Veh. Technol.*, St. Louis, MO, USA, May 1991, pages 57-62. These detectors require only a knowledge of the code of the data stream to be detected. If the codes of the data streams not to be detected are also known, interference caused by foreign data streams (due to non-orthogonal codes) can be determined and eliminated. CDMA detection can be improved significantly by appropriate multiuser methods. In addition to the optimal maximum likelihood detector, described, for example, by W. van Atten: "Maximum likelihood receiver for multiple channel transmission systems," *IEEE Trans. Commun.*, vol. 24 (1976) 276-283, several suboptimal methods are known, such as those described by W. Sauer-Greff and R. A. Kennedy: "Suboptimal MLSE for distorted multiple-access channels using the M-algorithm," *Proc. Aachener Kolloquium Signal Theorie*, Aachen, March 1994, 267-270; K. S. Schneider: "Detection of code division multiplexed signals," *IEEE Trans. Aerosp. Electron. Syst.*, vol. AES-15 (1979), 181-185; R. Lupas and S. Verdu: "Linear multi-user detectors for synchronous code division multiple-access channels," *IEEE Trans. Inform. Theory*, vol. 35 (1989) 123-136; Z. Xie, R. T. Short and C. K. Rushforth: "A family of suboptimum detectors for coherent multi-user communications," *IEEE J. Select. Areas Commun.*, vol. 8 (1990), 683-690; and A. Duel-Hallen: "Decorrelating decision-feedback multiuser detector for synchronous code-division

multiple-access channels," *IEEE Trans. Commun.*, vol. 41 (1993) 285-290.

If the pulse responses of the transmission channels of the coded data streams are known, interference caused by filtering can also be eliminated, as described by J. Salz: "Digital transmission over cross-coupled linear channels," *Bell Syst. Tech. J.*, vol. 64 (1985), 1147-1159; A. Duel-Hallen: Equalizers for multiple input/multiple output channels and PAM systems with cyclostationary input sequences," *IEEE J. Select. Areas Commun.*, vol. 10 (1992) 630-639; and M. L. Honig, P. Crespo and K. Steiglitz: "Suppression of near- and far-end crosstalk by linear pre- and post-filtering," *IEEE J. Select. Areas Commun.*, vol. 10 (1992), pages 614-629.

The greatest disadvantage of multiuser detectors is their high computational complexity. Even suboptimal methods often cannot be implemented because of the computational complexity. On the other hand, the RAKE receiver, which is simple in computing terms, offers greatly inferior detection results.

<u>Summary Of The Invention</u>

Therefore, an object of the present invention is to create a multiuser detection method and a corresponding device based on available computing capacity.

The method according to the present invention for detecting CDMA-coded signals $\underline{d} = (\underline{d}^{(1)}, \ldots, \underline{d}^{(K)})$, where $\underline{d}^{(k)} = (\underline{d}_1^{(k)}, \ldots, \underline{d}_M^{(k)})$, $k = 1, \ldots, K$, includes the following steps:

a) determining a first detection solution $\hat{\underline{d}}(1)$ of CDMA-coded signals $\underline{d}$;

b) calculating an (n+1)-th detection solution $\hat{\underline{d}}$ (n+1) by assigning $\hat{\underline{d}}(\mathrm{n}+1) = \mathrm{f}\left(\hat{\underline{d}}(\mathrm{n})\right)$ as a function of n-th detection solution $\hat{\underline{d}}(\mathrm{n})$ for n = 1, ..., N, where iteration for large values of n converges toward multiuser solution $\hat{\underline{d}}_{\mathrm{MU}}$, i.e.,

$$\mathrm{f}\left(\hat{\underline{\mathrm{d}}}(\mathrm{n})\right) \xrightarrow[n\to\infty]{} \hat{\underline{\mathrm{d}}}_{\mathrm{MU}},$$

c) if the quality of approximation solution $\hat{\underline{d}}(\mathrm{n}+1)$ is not sufficient, letting n → n+1 and

continuing the procedure with step b);

d) if the quality of solution $\hat{\underline{d}}(n+1)$ is sufficient, terminating the procedure and using $\hat{\underline{d}}(n+1)$ as the estimate of data $\underline{d}$ to be detected.

Symbols $\underline{d}^{(k)}$ to be transmitted can represent continuous or discrete data, the symbols preferably assuming values $\underline{d}^{(k)} = \pm 1, \pm i$ in the case of QPSK (quaternary phase shift keying) modulation.

The process preferably converges toward the solution of the zero forcing block linear estimator for $n \to \infty$.

Furthermore, the function of step b) can be formed by

$$f(\hat{\underline{d}}) = \hat{\underline{d}} + \delta \cdot \underline{g}$$

with a standardization factor

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2}$$

and an approximation term

$$\underline{g}^{T=A^H} \cdot \left(\underline{s}^T - A \cdot \hat{\underline{d}}^T\right),$$

where matrix A is given by

$$
\mathrm{A} = \begin{bmatrix}
b^{(1)}{}_1 & 0 & \cdots & \\
\vdots & \vdots & & \\
b^{(1))}{}_Q & 0 & & \vdots \\
\vdots & b^{(1)}{}_1 & & \\
b^{(1)}{}_{Q+W-1} & \vdots & & 0 \\
0 & b^{(1)}{}_{Q+W-1} & & b^{(K)}{}_1 \\
\vdots & \vdots & & \vdots \\
0 & 0 & \cdots & b^{(k)}{}_{Q+W-1}
\end{bmatrix}
$$

with $\underline{b}^{(k)} = \underline{c}^{(k)} * \underline{h}^{(k)}$

where $\underline{c}^{(k)}$ denotes the K different codes and $\underline{h}^{(k)}$ denotes the pulse responses of the K different linear transmission channels.

Solution $\hat{\underline{d}}^T(1) = \mathrm{A}^{\mathrm{H}} \cdot \underline{\mathrm{s}}^T$ of the RAKE receiver is preferably used as the l-st detection solution for starting the iteration. Furthermore, the first detection solution for starting the iteration can be set to zero.

A device according to the present invention for carrying out the method described above includes a data estimator for determining a first detection solution, an estimate improver for determining an improved detection solution and a decision circuit for deciding whether to continue the iteration.

The estimate improver preferably includes a unit for calculating an estimated transmission signal, a unit for calculating standardized approximation term $\delta \cdot \underline{g}$ and an adder for calculating the improved estimate. The unit for calculating standardized approximation term $\delta \cdot \underline{g}$ may have a unit for calculating approximation term $\underline{g}$, a unit for calculating

standardization factor δ and a multiplier for calculating the standardized approximation term.

A special advantage of the method according to the present invention is that the method requires only as much computing capacity as is available. The solution supplied is better than the solution of a RAKE receiver. If the available computing capacity is sufficient, the solution of the method according to the present invention approximates the solution of the multiuser method, i.e., the solution of the multiuser method is approximated by the method according to the present invention. By stipulating the time consumed by the method, it can be adapted easily to different complex detection functions, e.g., in the case of time-variable transmission channels of the CDMA system.

Brief Description Of The Drawings

Figure 1 shows a flow chart of the method according to the present invention.

Figure 2 shows a structural diagram of the detector.

Figure 3 shows a diagram of the estimate improver of the embodiment according to Figure 2.

Detailed Description

However, before giving a detailed explanation of the figures, the theory of the method will be outlined briefly.

Let there be K different discrete-time digital data streams

$$\underline{d}^{(k)} = \left(d^{(k)}{}_1,\ d^{(k)}{}_2, \ldots,\ d^{(k)}{}_M\right)$$

Symbols $\underline{d}^{(k)}$ to be transmitted may represent continuous or discrete data. Digital data is preferably represented by linear modulation on discrete complex values of symbols $\underline{d}^{(k)}$, the symbols assuming values of $\underline{d}^{(k)} = \pm 1$ or $\pm i$, for example, in QPSK (quaternary phase shift keying) modulation.

Let these be CDMA coded with K different codes accordingly

$$\underline{c}^{(k)} = \left(c^{(k)}{}_{1},\ \ldots,\ c^{(k)}{}_{Q}\right)$$

to:

$$\underline{a}^{(k)} = \left(d^{(k)}{}_{1} \cdot c^{(k)}{}_{1}, \ldots, d^{(k)}{}_{1} \cdot c^{(k)}{}_{Q}, \ldots, d^{(k)}{}_{M} \cdot c^{(k)}{}_{1}, \ldots, d^{(k)}{}_{M} \cdot c^{(k)}{}_{Q}\right)$$

Let these K signals be filtered through K different linear transmission channels having the pulse responses as follows:

$$\underline{h}^{(k)} = \left(h^{(k)}{}_{1}, \ldots, h^{(k)}{}_{W}\right)$$

to:

$$\underline{s}^{(k)} = \underline{a}^{(k)} * \underline{h}^{(k)}$$

Transmitted signals $\underline{s}^{(k)}$ and an additional noise $\underline{n}$ are added up to a total signal:

$$\underline{s} = \sum_{k=1}^{K} \underline{s}^{(k)} + \mathbf{n}\ .$$

With

$$\underline{d} = \left(\underline{d}^{(1)}, \ldots, \underline{d}^{(K)}\right),$$

$$A = \begin{bmatrix} b^{(1)}{}_1 & 0 & \cdots & \\ \vdots & \vdots & & \\ b^{(1))}{}_Q & 0 & & \vdots \\ \vdots & b^{(1)}{}_1 & & \\ b^{(1)}{}_{Q+W-1} & \vdots & & 0 \\ 0 & b^{(1)}{}_{Q+W-1} & & b^{(K)}{}_1 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & b^{(k)}{}_{Q+W-1} \end{bmatrix}$$

and

$\underline{b}^{(k)} = \underline{c}^{(k)} * \underline{h}^{(k)}$

$\underline{s}$ can be expressed by a linear equation system:

$\underline{s}^T = A \cdot \underline{d}^T + \underline{n}^T$

where $\underline{s}^T$ is the transposed term of vector $\underline{s}$.

Transmitted data streams can be estimated by a RAKE receiver from this receiver signal:

$$\hat{\underline{d}}^{T} = A^{H} \cdot \underline{s}^{T}$$

where A^H is the complex conjugated matrix transposed to A, and $\hat{\underline{d}}$ is the estimate of the data bits transmitted.

Better results are obtained with a multiuser method such as the zero forcing block linear

estimator:

$$\underline{\hat{d}}^T = (A^H \cdot A)^{-1} \cdot A^H \cdot \underline{s}^T \cdot$$

This solution may be approximated by iteration by repeated use of the following representation:

$$\underline{\hat{d}} \mapsto \underline{\hat{d}} + \delta \cdot g$$

where

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2}$$

and

$$\underline{g}^T = A^H \cdot (\underline{s}^T - A \cdot \underline{\hat{d}}^T) .$$

This method therefore includes the following steps:

i) Set $\underline{\hat{d}}$ to first estimate $\underline{\hat{d}}\ (1)$ for $\underline{d}$.

ii) Set $\underline{\hat{d}}$ to improved ((n+1)-th) estimate $\underline{\hat{d}} + \delta \cdot g$ with

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2} \textbf{ and } \underline{g}^T = A^H \cdot (\underline{s}^T - A \cdot \underline{\hat{d}}^T) \cdot$$

iii) If no more computing time is available, $\hat{\underline{d}}$ is assumed to be an estimate for transmitted data $\underline{d}$; otherwise the iteration is continued with step ii).

If $\hat{\underline{d}}_i^{(k)} = 0$ is assumed as starting values for data to be detected, this method yields the solution of the RAKE receiver in the first step.

This method is illustrated in Figure 1. The total signal, the required codes and the channel pulse responses are available as input E. In a first step 1, detection solution $\hat{\underline{d}}$ is set to a first estimate $\hat{\underline{d}}(1)$ of transmitted data $\underline{d}$. In a second step 2, detection solution $\hat{\underline{d}}(2)$ is set to an improved estimate $\hat{\underline{d}}(1) + \delta \cdot g$ using the definitions given above for δ and g. Step 3 which follows determines whether no more computing time is available or whether the improvement is sufficient. If this is the case, the iteration is terminated and the improved estimate is used as the solution. However, if more computing time is available or if the improvement is not sufficient, the process returns to second step 2, the improved estimate is used as the starting value and another iteration step is performed.

Figure 2 shows the structure of a detector which carries out the method described above. Input quantities include received signal $\underline{s}$ as well as codes $\underline{c}^{(k)}$ and pulse responses $\underline{h}^{(k)}$. In a data estimator 4, a first estimate of the data is made on the basis of these input quantities. This first estimate is entered into an estimate improver 5 via a double-throw switch 7. The first estimate of first data estimator 4 is improved in estimate improver 5 by using the method described above. A decision circuit 6 determines whether no more computing time is available or whether the improvement in the estimate is sufficient. In the case when more computing time is available and the improvement is not sufficient, the result of the first improvement is again sent as a new input value to the input of estimate improver 5 via double-throw switch 7, which is thrown. Therefore, iteration is continued. Otherwise, the estimate thus determined is used as the value of the data to be detected. Furthermore, the detector includes a convolution calculator 8 which calculates quantity $\underline{b}^{(k)}$ from codes $\underline{c}^{(k)}$ and channel pulse responses $\underline{h}^{(k)}$.

Figure 3 shows a block diagram of a preferred embodiment of estimate improver 5 of Figure 2. In a unit 9 for calculating the estimated transmission signal, the n-th estimate of the transmission signal is calculated with n-th estimate $\hat{\underline{d}}$ (n) of the data by calculating $A \cdot \hat{\underline{d}}$ (n) and then is subtracted from received transmission signal $\underline{s}$ in a subtractor 10. In a unit 11, standardized approximation term $\delta \cdot \underline{g}$ is calculated from the difference. This unit 11 includes a computation unit 12 for multiplying the difference by transposed matrix A^T, thereby calculating n-th approximation term $\underline{g}$. Furthermore, in a standardization unit 13, standardization factor δ is calculated from this term using the definition equation given above. Standardized approximation term $\delta \cdot \underline{g}$ is calculated in a multiplier 14 as the product of standardization factor δ and approximation term $\underline{g}$. Then (n+1)-th estimate $\hat{\underline{d}}$ (n+1) is formed in an adder 15 by addition of n-th estimate $\hat{\underline{d}}$ (n) and standardized (n)-th approximation term $\delta \cdot \underline{g}$.

Abstract Of The Disclosure

Multiuser methods of detecting CDMA-coded signals cannot be used in practice because of their high computational complexity. However, the RAKE receiver, which is simple in computing terms, offers greatly inferior detection results. Through an iterative approximation of multiuser solutions, a reduction in computing complexity is achieved in comparison with traditional multiuser methods. A first estimate of coded data is improved by iteration either until a quality criterion is met or until no more computing time is available. The field of application of this method includes, in particular, situations where CDMA-coded signals transmitted linearly are to be detected, in particular in the mobile wireless field when using CDMA methods.

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3) PRTS

[10191/1761]

METHOD AND DEVICE FOR DETECTING CDMA-CODED SIGNALS

The present invention relates to a method and a device for detecting CDMA-coded signals.

CDMA offers the possibility of combining multiple discrete-time data streams into a total signal such that the original data streams can be recovered from this signal. Data streams can be recovered if the CDMA-coded signals are modified by different linear filters. The simplest possibility of data detection is called a matched filter. Better results are obtained with a RAKE receiver, as described, for example, by A. Salmasi, K. S. Gilhousen: "On the system design aspects of code division multiplex access (CDMA) applied to digital cellular and personal communications network," *Proc. IEEE Conf. Veh. Technol.*, St. Louis, MO, USA, May 1991, pages 57-62. These detectors require only a knowledge of the code of the data stream to be detected. If the codes of the data streams not to be detected are also known, interference caused by foreign data streams (due to non-orthogonal codes) can be determined and eliminated. CDMA detection can be improved significantly by appropriate multiuser methods. In addition to the optimal maximum likelihood detector, described, for example, by W. van Atten: "Maximum likelihood receiver for multiple channel transmission systems," *IEEE Trans. Commun.*, vol. 24 (1976) 276-283, several suboptimal methods are known, such as those described by W. Sauer-Greff and R. A. Kennedy: "Suboptimal MLSE for distorted multiple-access channels using the M-algorithm," *Proc. Aachener Kolloquium Signal Theorie*, Aachen, March 1994, 267-270; K. S. Schneider: "Detection of code division multiplexed signals," *IEEE Trans. Aerosp. Electron. Syst.*, vol. AES-15 (1979), 181-185; R. Lupas and S. Verdu: "Linear multi-user detectors for synchronous code division multiple-access channels," *IEEE Trans. Inform. Theory*, vol. 35 (1989) 123-136; Z. Xie, R. T. Short and C. K. Rushforth: "A family of suboptimum detectors for coherent multi-user communications," *IEEE J. Select. Areas Commun.*, vol. 8 (1990), 683-690; and A. Duel-Hallen: "Decorrelating decision-feedback multiuser detector for synchronous code-division multiple-access channels," *IEEE Trans. Commun.*, vol. 41 (1993) 285-290.

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If the pulse responses of the transmission channels of the coded data streams are known, interference caused by filtering can also be eliminated, as described by J. Salz: "Digital transmission over cross-coupled linear channels," *Bell Syst. Tech. J.*, vol. 64 (1985), 1147-1159; A. Duel-Hallen: Equalizers for multiple input/multiple output channels and PAM systems with cyclostationary input sequences," *IEEE J. Select. Areas Commun.*, vol. 10 (1992) 630-639; and M. L. Honig, P. Crespo and K. Steiglitz: "Suppression of near- and far-end crosstalk by linear pre- and post-filtering," *IEEE J. Select. Areas Commun.*, vol. 10 (1992), pages 614-629.

The greatest disadvantage of multiuser detectors is their high computational complexity. Even suboptimal methods often cannot be implemented because of the computational complexity. On the other hand, the RAKE receiver, which is simple in computing terms, offers greatly inferior detection results.

Therefore, the object of the present invention is to create a multiuser detection method and a corresponding device based on available computing capacity.

This object is achieved by the method having the features of Claim 1 and the device having the features of Claim 7. Preferred embodiments of the present invention are the object of the subordinate claims.

The method according to the present invention for detecting CDMA-coded signals $\underline{d} = (\underline{d}^{(l)}$, ..., $\underline{d}^{(K)})$, where $\underline{d}^{(k)} = (\underline{d}_l^{(k)}$, ..., $\underline{d}_M^{(k)})$, $k = 1$, ..., K, includes the following steps:

a) determining a first detection solution $\hat{\underline{d}}(1)$ of CDMA-coded signals $\underline{d}$;

b) calculating an (n+1)-th detection solution $\hat{\underline{d}}$ (n+1) by assigning $\hat{\underline{d}}(\mathrm{n}+1) = \mathrm{f}(\hat{\underline{d}}(\mathrm{n}))$ as a function of n-th detection solution $\hat{\underline{d}}(\mathrm{n})$ for n = 1, ..., N, where iteration for large values of n converges toward multiuser solution $\hat{\underline{d}}_{\mathrm{MU}}$, i.e.,

$$\mathrm{f}(\hat{\underline{\mathrm{d}}}(\mathrm{n})) \xrightarrow[n\to\infty]{} \hat{\underline{\mathrm{d}}}_{\mathrm{MU}},$$

c) if the quality of approximation solution $\hat{\underline{d}}(\mathrm{n}+1)$ is not sufficient, letting n → n+1 and continuing the procedure with step b);

d) if the quality of solution $\hat{\underline{d}}(\mathrm{n}+1)$ is sufficient, terminating the procedure and using $\hat{\underline{d}}(\mathrm{n}+1)$ as the estimate of data $\underline{d}$ to be detected.

Symbols $\underline{d}^{(k)}$ to be transmitted can represent continuous or discrete data, the symbols preferably assuming values $\underline{d}^{(k)} = \pm 1, \pm i$ in the case of QPSK (quaternary phase shift keying) modulation.

The process preferably converges toward the solution of the zero forcing block linear estimator for n → ∞.

Furthermore, the function of step b) can be formed by

$$\mathrm{f}(\hat{\underline{\mathrm{d}}}) = \hat{\underline{\mathrm{d}}} + \delta \cdot \underline{g}$$

with a standardization factor

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2}$$

and an approximation term

$$\underline{g}^{T=A^H} \cdot \left(\underline{s}^T - A \cdot \hat{\underline{d}}^T\right),$$

where matrix A is given by

$$
A = \begin{bmatrix}
b^{(1)}_1 & 0 & \cdots & \\
\vdots & \vdots & & \\
b^{(1))}_Q & 0 & & \vdots \\
\vdots & b^{(1)}_1 & & \\
b^{(1)}_{Q+W-1} & \vdots & & 0 \\
0 & b^{(1)}_{Q+W-1} & & b^{(K)}_1 \\
\vdots & \vdots & & \vdots \\
0 & 0 & \cdots & b^{(k)}_{Q+W-1}
\end{bmatrix}
$$

with $\underline{b}^{(k)} = \underline{c}^{(k)} * \underline{h}^{(k)}$

where $\underline{c}^{(k)}$ denotes the K different codes and $\underline{h}^{(k)}$ denotes the pulse responses of the K different linear transmission channels.

Solution $\underline{\hat{d}}^T(1) = \mathrm{A}^{\mathrm{H}} \cdot \underline{\mathrm{s}}^T$ of the RAKE receiver is preferably used as the 1-st detection solution for starting the iteration. Furthermore, the first detection solution for starting the iteration can be set to zero.

A device according to the present invention for carrying out the method described above includes a data estimator for determining a first detection solution, an estimate improver for determining an improved detection solution and a decision circuit for deciding whether to continue the iteration.

The estimate improver preferably includes a unit for calculating an estimated transmission signal, a unit for calculating standardized approximation term $\delta \cdot \underline{g}$ and an adder for calculating the improved estimate. The unit for calculating standardized approximation term $\delta \cdot \underline{g}$ may have a unit for calculating approximation term $\underline{g}$, a unit for calculating

standardization factor δ and a multiplier for calculating the standardized approximation term.

A special advantage of the method according to the present invention is that the method requires only as much computing capacity as is available. The solution supplied is better than the solution of a RAKE receiver. If the available computing capacity is sufficient, the solution of the method according to the present invention approximates the solution of the multiuser method, i.e., the solution of the multiuser method is approximated by the method according to the present invention. By stipulating the time consumed by the method, it can be adapted easily to different complex detection functions, e.g., in the case of time-variable transmission channels of the CDMA system.

A preferred embodiment of the present invention is explained below with reference to the drawings.

Figure 1 shows a flow chart of the method according to the present invention,

Figure 2 shows a structural diagram of the detector, and

Figure 3 shows a diagram of the estimate improver of the embodiment according to Figure 2.

However, before giving a detailed explanation of the figures, the theory of the method will be outlined briefly.

Let there be K different discrete-time digital data streams

$$\underline{d}^{(k)} = \left(d^{(k)}_{1},\ d^{(k)}_{2}, \ldots,\ d^{(k)}_{M}\right)$$

Symbols $\underline{d}^{(k)}$ to be transmitted may represent continuous or discrete data. Digital data is preferably represented by linear modulation on discrete complex values of symbols $\underline{d}^{(k)}$, the symbols assuming values of $\underline{d}^{(k)} = \pm 1$ or $\pm i$, for example, in QPSK (quaternary phase shift keying) modulation.

Let these be CDMA coded with K different codes accordingly

$$\underline{c}^{(k)} = \left(c^{(k)}{}_{1},\ \ldots,\ c^{(k)}{}_{Q}\right)$$

to:

$$\underline{a}^{(k)} = \left(d^{(k)}{}_{1} \cdot c^{(k)}{}_{1},\ldots,d^{(k)}{}_{1} \cdot c^{(k)}{}_{Q},\ldots,d^{(k)}{}_{M} \cdot c^{(k)}{}_{1},\ldots,d^{(k)}{}_{M} \cdot c^{(k)}{}_{Q}\right)$$

Let these K signals be filtered through K different linear transmission channels having the pulse responses as follows:

$$\underline{h}^{(k)} = \left(h^{(k)}{}_{1},\ldots,h^{(k)}{}_{W}\right)$$

to:

$$\underline{s}^{(k)} = \underline{a}^{(k)} * \underline{h}^{(k)}$$

Transmitted signals $\underline{s}^{(k)}$ and an additional noise $\underline{n}$ are added up to a total signal:

$$\underline{s} = \sum_{k=1}^{K} \underline{s}^{(k)} + n\,.$$

With

$$\underline{d} = \left(\underline{d}^{(1)},\ldots,\underline{d}^{(K)}\right),$$

$$A = \begin{bmatrix} b^{(1)}{}_1 & 0 & \cdots & \\ \vdots & \vdots & & \\ b^{(1))}{}_Q & 0 & & \vdots \\ \vdots & b^{(1)}{}_1 & & \\ b^{(1)}{}_{Q+W-1} & \vdots & & 0 \\ 0 & b^{(1)}{}_{Q+W-1} & & b^{(K)}{}_1 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & b^{(k)}{}_{Q+W-1} \end{bmatrix}$$

and

$$\underline{b}^{(k)} = \underline{c}^{(k)} * \underline{h}^{(k)}$$

$\underline{s}$ can be expressed by a linear equation system:

$$\underline{s}^T = A \cdot \underline{d}^T + \underline{n}^T$$

where $\underline{s}^T$ is the transposed term of vector $\underline{s}$.

Transmitted data streams can be estimated by a RAKE receiver from this receiver signal:

$$\hat{\underline{d}}^T = A^H \cdot \underline{s}^T$$

where A^H is the complex conjugated matrix transposed to A, and $\hat{\underline{d}}$ is the estimate of the data bits transmitted.

Better results are obtained with a multiuser method such as the zero forcing block linear

estimator:

$$\underline{\hat{d}}^{T} = (A^{H} \cdot A)^{-1} \cdot A^{H} \cdot \underline{s}^{T} \cdot$$

This solution may be approximated by iteration by repeated use of the following representation:

$$\underline{\hat{d}} \mapsto \underline{\hat{d}} + \delta \cdot g$$

where

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2}$$

and

$$\underline{g}^{T} = A^{H} \cdot (\underline{s}^{T} - A \cdot \underline{\hat{d}}^{T}) .$$

This method therefore includes the following steps:

i) Set $\underline{\hat{d}}$ to first estimate $\underline{\hat{d}}\ (1)$ for $\underline{d}$.

ii) Set $\underline{\hat{d}}$ to improved ((n+1)-th) estimate $\underline{\hat{d}} + \delta \cdot g$ with

$$\delta = \frac{\|g\|^2}{\|A \cdot g\|^2} \quad \textbf{and} \quad \underline{g}^{T} = A^{H} \cdot (\underline{s}^{T} - A \cdot \underline{\hat{d}}^{T}) \cdot$$

iii) If no more computing time is available, $\hat{\underline{d}}$ is assumed to be an estimate for transmitted data $\underline{d}$; otherwise the iteration is continued with step ii).

If $\hat{\underline{d}}_i^{(k)} = 0$ is assumed as starting values for data to be detected, this method yields the solution of the RAKE receiver in the first step.

This method is illustrated in Figure 1. The total signal, the required codes and the channel pulse responses must be available as input E. In a first step 1, detection solution $\hat{\underline{d}}$ is set to a first estimate $\hat{\underline{d}}(1)$ of transmitted data $\underline{d}$. In a second step 2, detection solution $\hat{\underline{d}}(2)$ is set to an improved estimate $\hat{\underline{d}}(1) + \delta \cdot g$ using the definitions given above for δ and g. Step 3 which follows determines whether no more computing time is available or whether the improvement is sufficient. If this is the case, the iteration is terminated and the improved estimate is used as the solution. However, if more computing time is available or if the improvement is not sufficient, the process returns to second step 2, the improved estimate is used as the starting value and another iteration step is performed.

Figure 2 shows the structure of a detector which carries out the method described above. Input quantities include received signal $\underline{s}$ as well as codes $\underline{c}^{(k)}$ and pulse responses $\underline{h}^{(k)}$. In a data estimator 4, a first estimate of the data is made on the basis of these input quantities. This first estimate is entered into an estimate improver 5 via a double-throw switch 7. The first estimate of first data estimator 4 is improved in estimate improver 5 by using the method described above. A decision circuit 6 determines whether no more computing time is available or whether the improvement in the estimate is sufficient. In the case when more computing time is available and the improvement is not sufficient, the result of the first improvement is again sent as a new input value to the input of estimate improver 5 via double-throw switch 7, which is thrown. Therefore, iteration is continued. Otherwise, the estimate thus determined is used as the value of the data to be detected. Furthermore, the detector includes a convolution calculator 8 which calculates quantity $\underline{b}^{(k)}$ from codes $\underline{c}^{(k)}$ and channel pulse responses $\underline{h}^{(k)}$.

Figure 3 shows a block diagram of a preferred embodiment of estimate improver 5 of Figure 2. In a unit 9 for calculating the estimated transmission signal, the n-th estimate of the transmission signal is calculated with n-th estimate $\hat{\underline{d}}$ (n) of the data by calculating $A \cdot \hat{\underline{d}}$ (n) and then is subtracted from received transmission signal $\underline{s}$ in a subtractor 10. In a unit 11, standardized approximation term $\delta \cdot \underline{g}$ is calculated from the difference. This unit 11 includes a computation unit 12 for multiplying the difference by transposed matrix A^T, thereby calculating n-th approximation term $\underline{g}$. Furthermore, in a standardization unit 13, standardization factor δ is calculated from this term using the definition equation given above. Standardized approximation term $\delta \cdot \underline{g}$ is calculated in a multiplier 14 as the product of standardization factor δ and approximation term $\underline{g}$. Then (n+1)-th estimate $\hat{\underline{d}}$ (n+1) is formed in an adder 15 by addition of n-th estimate $\hat{\underline{d}}$ (n) and standardized (n)-th approximation term $\delta \cdot \underline{g}$.

New claims: What is claimed is:

1. A method for detecting CDMA-coded signals $\underline{d} = (\underline{d}^{(1)}, ..., \underline{d}^{(K)})$, where $\underline{d}^{(k)} = (\underline{d}_1^{(k)}, ..., \underline{d}_M^{(k)})$, $k = 1, ..., K$, characterized in that the method comprises the following steps:

a) determining a first detection solution $\hat{\underline{d}}(1)$ of CDMA-coded signals $\underline{d}$;

b) determining an (n+1)-th detection solution $\hat{\underline{d}}(n+1)$ for n = 1, ..., N as a function of the n-th detection solution $\hat{\underline{d}}(n)$ by assigning

$$\hat{\underline{d}}(n+1) = f(\hat{\underline{d}}(n))$$

where iteration for $n \to \infty$ converges toward multiuser solution $\hat{\underline{d}}_{MU}$, i.e.,

$$f(\hat{\underline{d}}(n)) \xrightarrow[n\to\infty]{} \hat{\underline{d}}_{MU},$$

c) if the quality of approximation solution $\hat{\underline{d}}(n+1)$ is not sufficient, assigning $n \to n+1$ and continuing the procedure with step b);

d) if the quality of solution $\hat{\underline{d}}(n+1)$ is sufficient, terminating the procedure and using $\hat{\underline{d}}(n+1)$ as the estimate of data $\underline{d}$ to be detected,

e) the function of step b is given by

$$f(\hat{\underline{d}}) = \hat{\underline{d}} + \delta \cdot \underline{g}$$

with

$$\delta = \frac{\|\underline{g}\|^2}{\|A \cdot \underline{g}\|^2} \textbf{ and } \underline{g}^T = A^H \cdot (\underline{s}^T - A \cdot \hat{\underline{d}}^T)$$

where matrix A is given by

$$A = \begin{bmatrix} b^{(1)}_1 & 0 & \cdots & \\ \vdots & \vdots & & \\ b^{(1))}_Q & 0 & & \vdots \\ \vdots & b^{(1)}_1 & & \\ b^{(1)}_{Q+W-1} & \vdots & & 0 \\ 0 & b^{(1)}_{Q+W-1} & & b^{(K)}_1 \\ \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & b^{(k)}_{Q+W-1} \end{bmatrix}$$

with $\underline{b}^{(k)} = \underline{c}^{(k)} * \underline{h}^{(k)}$,

where $\underline{c}^{(k)}$ denotes the K different codes and $\underline{h}^{(k)}$ denotes the pulse responses of the K different linear transmission channels.

2. The method according to Claim 1,
characterized in that the method converges toward the solution of the zero forcing block linear estimator for $n \rightarrow \infty$.

3. The method according to one of the preceding claims, characterized in that symbols $d^{(k)}$ to be transmitted assume values of ± 1 or $\pm i$.

4. The method according to one of the preceding claims, characterized in that solution $\hat{\underline{d}}^T(n) = A^H \cdot \underline{s}^T$ of the RAKE receiver is used as the l-st detection solution for starting the iteration.

5. The method according to one of Claims 1 through 3, characterized in that the first detection solution for starting the iteration is set to zero.

6. A device for carrying out the method according to one of Claims 1 through 5, characterized in that the device has a data estimator (4) for determining a first detection solution, an estimate improver (5) for determining an improved detection solution and a decision circuit (6) for deciding whether to continue the iteration.

7. The device according to Claim 6,
characterized in that the estimate improver (5) has a unit (9) for calculating an estimated transmission signal, a unit (11) for calculating standardized approximation term $\delta \cdot \underline{g}$ and an adder (15) for calculating the improved estimate.

8. The device according to Claim 7,
characterized in that the unit (11) for calculating standardized approximation term $\delta \cdot \underline{g}$ has a unit (12) for calculating approximation term $\underline{g}$, a unit (13) for calculating standardization factor δ and a multiplier (14) for calculating the standardized approximation term.

Abstract

Multiuser methods of detecting CDMA-coded signals cannot be used in practice because of their high computational complexity. However, the RAKE receiver, which is simple in computing terms, offers greatly inferior detection results.

Through an iterative approximation of multiuser solutions, the method according to the present invention reduces computing complexity in comparison with traditional multiuser methods. A first estimate of coded data is improved by iteration either until a quality criterion is met or until no more computing time is available.

The field of application of this method includes, in particular, situations where CDMA-coded signals transmitted linearly are to be detected, in particular in the mobile wireless field when using CDMA methods.

(Figure 1)

Fig. 1

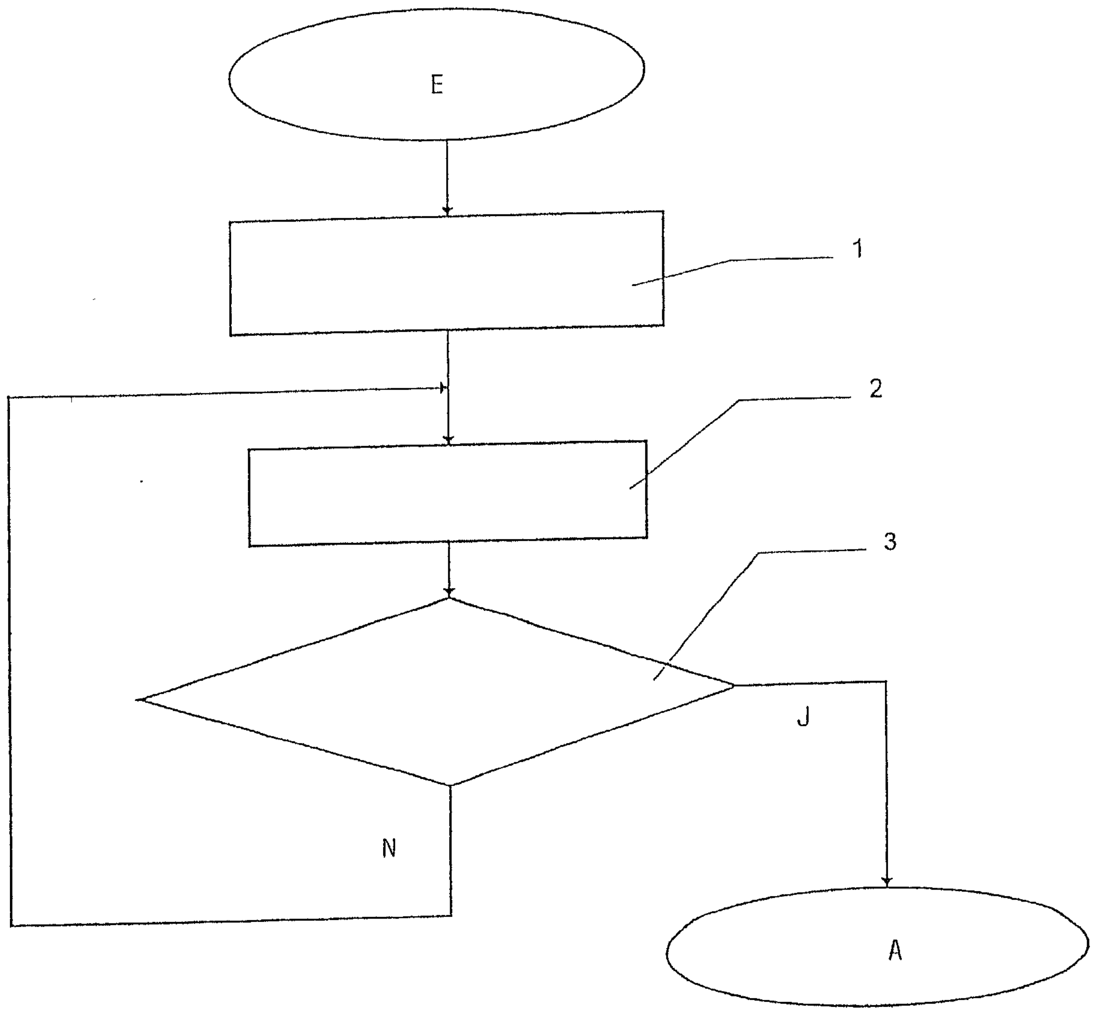


Fig. 2

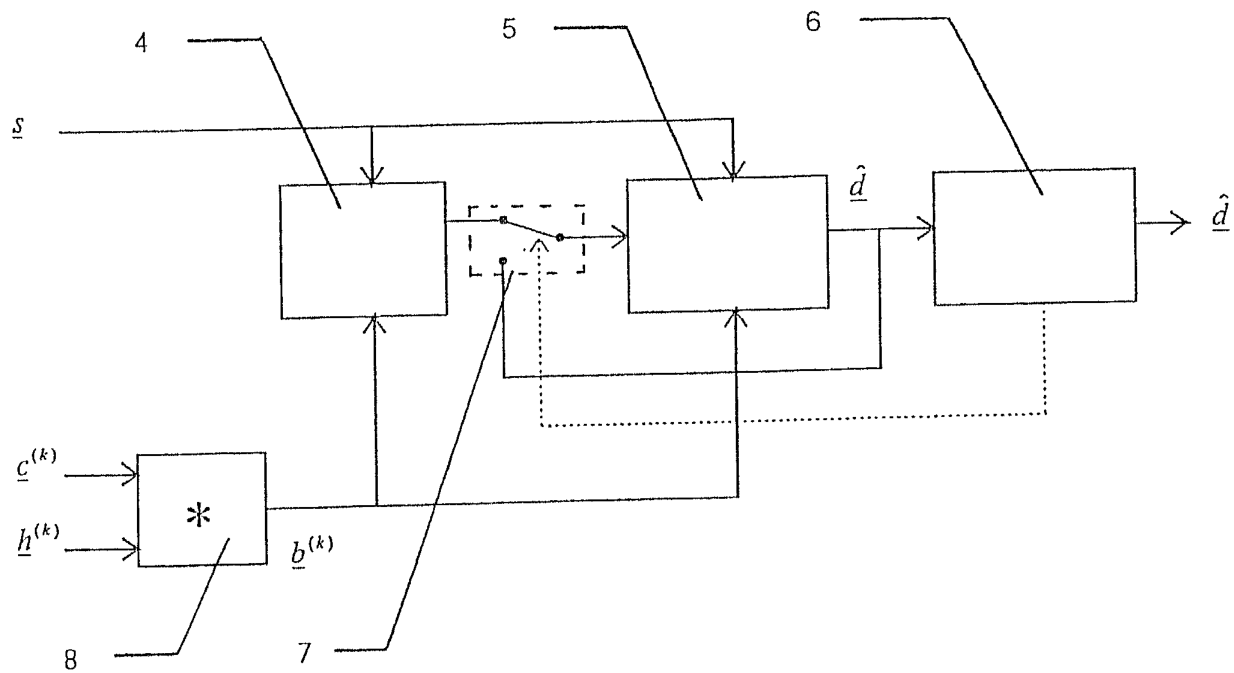
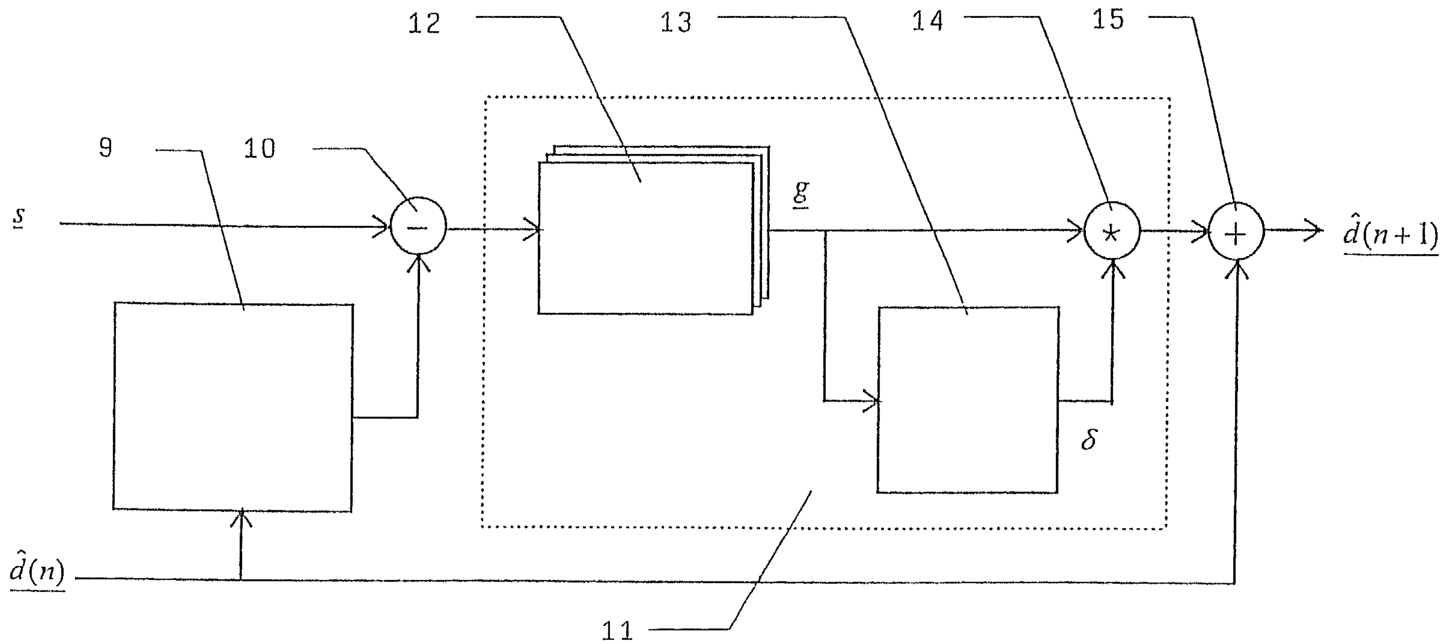

4
5
6
$\underline{s}$
$\hat{\underline{d}}$
$\hat{\underline{d}}$
$\underline{c}^{(k)}$
$\underline{h}^{(k)}$
*
$\underline{b}^{(k)}$
8
7

Fig. 3



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COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **METHOD AND DEVICE FOR DETECTING CDMA-CODED SIGNALS**, and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No. _________ on _________, 19__ and was amended by the Preliminary Amendment filed on ____________, 19__.

[X] was filed as PCT International Application Number PCT/DE99/02156 on the 13th day of July, 1999.

[X] an English translation of which is filed herewith.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

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PRIOR FOREIGN/PCT APPLICATION(S)
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119

Country : Federal Republic of Germany

Application No. : 198 41 578.8

Date of Filing: September 11, 1998

Priority Claimed
Under 35 U.S.C. § 119 : [X] Yes [ ] No

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PCT INTERNATIONAL APPLICATIONS
DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120

U.S. APPLICATIONS

Number :

Filing Date :

PCT APPLICATIONS
DESIGNATING THE U.S.

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1.00

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